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METHODOLOGY FOR ESTIMATING NATURAL HYDROCARBON EMISSIONS

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$$\text{Emissions} = \Sigma \text{ Biomass} * \text{Area} * \text{Emission Factor}$$

It accommodates multiple sources with emission factors dependent on season, temperature and solar intensity. It provides emissions on a latitude/longitude based grid system aggregated by plant specie, hydrocarbon compound, study area (county, state, etc.), or time interval. The emission calculations from this inventory have better spatial, source, temporal and hydrocarbon compound resolution than prior work has provided.

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An emission inventory system for biogenic sources of hydrocarbons has been developed. It is based on modifications of the classic formula:

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INTRODUCTION

Part of the evaluation of the Regional Acid Deposition Modeling effort will include natural source contributions and effects. The new chemistry model has been extended to incorporate biogenic hydrocarbons in the simulation. The use of kinetic reactions employing natural sources of hydrocarbons in air and water requires definition of their emissions. Such an emission inventory should recognize production of biogenic hydrocarbons from:

- the foliage of trees, shrubs, and crops
- decaying leaf litter
- grasses in urban areas, pastures, and grasslands
- decaying vegetation in rivers, lakes, marshes, and oceans.

Methane, monoterpenes, and isoprene are the dominant hydrocarbon compounds produced by biogenic sources.

A systematic methodology was needed for the estimation of biogenic hydrocarbon emissions. Such an inventory should have the following capabilities:

- Generate hourly gridded emissions
  - (a) for a variable number of hydrocarbon species;
  - (b) from a variable number of plant species, leaf litter, and surface waters;
  - (c) for any latitude/longitude-based grid system.
- Apply temporal variations to emission factors on a diurnal and/or seasonal basis.
- Adjust emission factors for variations in temperature and solar radiation.
- Allow for future modification of emission factors to incorporate submodel calculations, including leaf temperature, foliar density, soil types, moisture availability, and disease prevalence.
- Provide summary reports of emissions by grid cell, county, U.S. Forest Service (USFS) region, and state.

Such a system has been developed for the Northeastern United States and offers the potential for meeting one of the requirements of the Regional Acid Deposition Model.

DISCUSSION

Biogenic hydrocarbon emissions are a function of emission rate and biomass within a given area. An emission inventory for them includes of building files of descriptive data on land use, emitter density, and emission factors. It also includes algorithms implementing the relations between the data elements of these descriptive files.

Area categorization has been primarily derived from the USGS Land Use and Land Cover map series supplemented as needed from other satellite

and aerial sources. Coverage areas for the following land use classifications were estimated to the nearest five percent for each grid cell:

- -urban
- -agricultural
- -rangeland
- -deciduous forest
- -coniferous forest
- -mixed forest (including forested wetland)
- -water
- -barren land
- -nonforested wetland
- -mixed agricultural and rangeland
- -rocky open areas occupied by low growing shrubs and lichen (not including tundra)

Mixed forest was split between the coniferous and deciduous classifications, with data from the U. S. Forest Service inventories used to allocate area to individual species. The canopy area is a function of the diameter at breast height (dbh), which is divided into ten intervals or classes. The area for one tree in a dbh class multiplied by the number of trees in the class and summed across classes gives the total area for a specie. A mix ratio of the specie area to the total area summed across all species of the same forest type, deciduous or coniferous, was used to allocate the proportion of the corresponding forest type area to that specie. Agricultural land was apportioned among crops based on the 1978 Census of Agriculture as aggregated to the county level by the Oak Ridge National Laboratory. Several state atlases were used to resolve the split between fresh and salt water, especially in estuaries. A file of the overlap between grid cells and study unit (county, forest region, etc.) was used to partition classification areas among the grid cells. It is used in reverse to summarize emissions at the study unit level.

Most of the hydrocarbons emitted by vegetation are released by the foliage. The branches, twigs, bole, and root emissions are negligible in

comparison. Foliage weight can be estimated from algorithms which relate foliage weight to tree diameters. Tree diameter inventories are compiled by the U. S. Forest Service for each state. Emission factors for surface waters, leaf litter, and some crops are area dependent and do not require a foliar weight estimate.

The emission factor is expressed as moles or micrograms of hydrocarbon emitted over a time interval per unit of land area or dry foliar weight. The identity of the hydrocarbons emitted is reported as isoprene, monoterpene, and/or unspecified nonmethane hydrocarbon. When emission factors were unavailable for a particular vegetative type, an emission factor from a biologically similar vegetation type was used. These emission factors have several possible sources of error:

- Measurement error due to the experimental method employed disturbing the natural emission process.
- Inappropriate substitution of emission factors due to unavailable data.
- Emission factors may vary with environmental parameters including geographic location, soil conditions, and elevation.

Because emission factors are known to vary with light and temperature, the system accounts for seasonal changes in solar radiation and surface temperature. It is assumed that the leaves of all plants are exposed to full sun and the same surface temperature. Because there may be large variations in solar radiation and surface temperature, hourly estimates are made of these variables. Solar radiation is derived from formulas that give the solar zenith angle as a function of latitude, longitude, date, and time of day. The system does not currently account for attenuation due to clouds and aerosols, but provision has been made for this variable in future versions of the system. Thus, the emissions

generated by the system are maximum rates with respect to the effects of sunlight. Surface temperatures from the National Weather Service are transformed to average grid cell temperatures by an objective mapping technique for mesoscale processes based on numerical filtering. All of the emission factors have been standardized to 30°C. It has been assumed that all monoterpene emitters and nonmethane hydrocarbon emitters (other than isoprene) respond to temperature in a manner similar to monoterpene emissions from slash pine. Likewise all isoprene emitters have been assumed to respond to changes in light and temperature as does isoprene from live oak.

CONCLUSIONS

An emission inventory system has been developed to meet the requirements of the new kinetic reactions employing natural sources of hydrocarbons in air and water. It provides much better resolution than prior inventories especially in terms of spatial and temporal variation. It is open ended allowing inclusion of different areas, sources, emission factors and temporial variations. It will provide insight into the relative contribution of a few species to the total emissions in an area. A systematic, detailed inventory increases the confidence in the emissions since variances can be reasonably calculated. Future research on emission factor development, module extensions, etc. can be guided by the knowledge gained from the system.